- 1 -

DISPLAY APPARATUS

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a display apparatus having a plurality of display panels (i.e., a

5 plurality of display areas).

Description of the Related Art

As the conventional technologies, in U.S Patent Application Publication No. 2001/0052887 (JP-A-2001-356746), a partial display has been described,

10 which performs a display in a partial area on the display panel. Namely, in U.S Patent Application Publication No. 2001/0052887, when a partial display instruction is issued in the driving of a display apparatus such as a liquid-crystal display apparatus

15 equipped with pixels of an n-row × m-column matrix, the partial display is performed, as follows: During one frame time-period, the respective rows of a settable s-row × m-column partial display area are sequentially selected out of the n-row × m-column matrix, then

20 writing predetermined partial display data into the respective rows. Moreover, predetermined background display data such as off-display (i.e., white-display) data is written into a background area which is the remainder of the partial display area. At this time,

only a k-row × m-column background area is selected during the one frame time-period, then writing the background display data therein. The k rows to be selected are shift-processed on each frame basis, and the entire background area is selected once during the time-period of (n-s)/k frames. The writing-in of the background display data is performed in such a manner that the polarity with respect to a reference voltage is inverted on each predetermined time-period basis. This allows the pixels in the background area to be securely inversion-driven with the off-display data. In U.S Patent Application Publication No. 2001/0052887, however, no description has been given concerning the driving of two display panels.

Also, in U.S Patent No. 6,396,469 (JP-A-11-109921), a display apparatus has been disclosed, which drives two pixel arrays independently of each other by using different data drivers. Namely, in U.S Patent No. 6,396,469, there is provided the following control unit: In order to display an image on the liquid-crystal panel in one time-period within a period during which one image is displayed, the control unit controls a gate-line driving unit so that a gate line will be selected for each of the first and second pixel arrays, and controls the first and second data drivers so that an image signal for displaying the image will be supplied to first and second data-line groups. In addition, in another time-period included within the

same period as that of the one time-period and

differing from the one time-period, the control unit

controls the gate-line driving unit so that the gate

line will be selected again for each of the first and

5   second pixel arrays, and controls the first and second

data drivers so that a non-image signal, which has a

predetermined electric potential and differs from the

image signal, will be supplied to the first and second

data-line groups. In U.S Patent No. 6,396,469, however,

10   no description has been given concerning the driving of

the two pixel arrays by using the one data driver.

Also, in U.S Patent No. 5,670,970 (JP-A-07-

175448), the disclosure has been made regarding the

driving of two liquid-crystal panels by using one

15   driver. Namely, in U.S Patent No. 5,670,970, there are

provided the XY-matrix-type first and second liquid-

crystal panels which have a switching element and a

storage element on each pixel basis, and a liquid-

crystal driving apparatus. Here, this liquid-crystal

20   driving apparatus supplies the first and second liquid-

crystal panels with an image signal whose polarity is

inverted on each predetermined period basis, so that

polarities of the image signals simultaneously supplied

to the first and second liquid-crystal panels will

25   become mutually opposite polarities. In U.S Patent No.

5,670,970, however, no description has been given

concerning the feeding of different image signals to

the two liquid-crystal panels.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a display apparatus which is capable of driving a plurality of display panels independently of each other by using a common circuit common thereto, and further, which is capable of reducing the power consumption.

In the present invention, a data driver is configured to be able to apply a tone voltage corresponding to both display data on a main screen and display data on a sub screen, and a scan driver is configured to be able to drive both a driving line for the main screen and a driving line for the sub screen. This configuration results in the implementation of a configuration that the single data driver and the single scan driver allow the two screens to be driven as if one screen were driven.

Moreover, in the present invention, if either of the two screens is set on non-display, a display synchronization signal for only a screen to be displayed (e.g., main screen) is accepted. In addition, during a vertical blanking time-period of the display synchronization signal, the non-displayed screen (e.g., sub screen) is scanned.

According to the present invention, of the plurality of display panels, the scanning period of a display panel set in the non-displayed state becomes smaller. This makes it possible to reduce the power

consumption.

According to the present invention, a part or the whole of a tone-voltage generating circuit is stopped when none of the display panels is scanned.

5   This makes it possible to reduce the power consumption.

Other objects, features and advantages of the invention will become apparent from the following description of the embodiments of the invention taken in conjunction with the accompanying drawings.

10   BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1A and FIG. 1B illustrate overviews of a folded-type mobile telephone having two screens of the present invention;

FIG. 2A and FIG. 2B illustrate an overview of
15   a display apparatus having two screens of the present invention, and operation signals of the display apparatus;

FIG. 3 illustrates a circuit configuration of the display apparatus in a first embodiment of the
20   present invention;

FIG. 4 illustrates contents of a control register 312 in the first embodiment of the present invention;

FIG. 5 illustrates an issuing sequence of
25   instructions in the first embodiment of the present invention;

FIG. 6 illustrates operation signals of a

timing adjusting unit 313 in the first embodiment of the present invention;

FIG. 7 illustrates a circuit configuration of a scan driver 202 in the first embodiment of the present invention;

FIG. 8 illustrates operation signals of a scanning-pulse generating circuit 703 in the first embodiment of the present invention;

FIG. 9 illustrates another circuit configuration of the display apparatus in the first embodiment of the present invention;

FIG. 10 illustrates operation signals of the display apparatus in a second embodiment of the present invention;

FIG. 11 illustrates a circuit configuration of the display apparatus in the second embodiment of the present invention; and

FIG. 12 illustrates a circuit configuration of a tone-voltage generating unit 1115 in the second embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Referring to FIG. 1 to FIG. 9, the explanation will be given below concerning the configuration of a display apparatus in a first embodiment of the present invention.

FIG. 1A and FIG. 1B illustrate overviews of a folded-type mobile telephone using two screens. The

mobile telephone uses the following two screens: A
main screen (i.e., inner-side large screen) as
illustrated in FIG. 1A for performing telephone-number
and character inputs, respective types of mobile-
5   telephone settings, and the like, and, a sub screen
(i.e., outer-side small screen) as illustrated in FIG.
1B for displaying information in a state as well where
the mobile telephone is folded. Here, in order to
reduce the power consumption of the two-screen-used
10   mobile telephone down to the lowest possible degree,
its displayed state is controlled as follows: The sub
screen is set on non-display when the main screen is
used, whereas, in the reception-awaiting state (i.e.,
the state of being folded), the display is performed on
15   the sub screen and the main screen is set on non-
display. Moreover, a data driver for driving the main
screen and a data driver for driving the sub screen are
identical and are common to the two screens (i.e., a
common LSI). Meanwhile, a scan driver for driving the
20   main screen and a scan driver for driving the sub
screen are different from each other (i.e., different
LSIs).

Referring to FIG. 2A and FIG. 2B, the
explanation will be given below regarding the operation
25   outline of the present embodiment. In FIG. 2A,
reference numerals 201, 202, 203 and 204 denote the
data driver, the scan driver, the main screen and the
sub screen, respectively. TFT (: Thin Film Transistor)

liquid crystal is used as both screens. Here, data
lines for the main screen 203 and data lines for the
sub screen 204 are configured to be identical and are
common to the two screens, and the scan driver 202 is

5   configured to be able to drive both a driving line for
the main screen 203 and a driving line for the sub
screen 204. This configuration, accordingly, allows
the above-described one set of drivers to drive the two
screens.

10   Next, in FIG. 2B, if it is assumed that the
main screen 203 is in the displayed state and the sub
screen 204 is in the non-displayed state, display
synchronization signals and display data 205 which are
necessary for causing the main screen 203 to perform an

15   image display are transferred from the outside. The
detailed items of the display synchronization signals
and display data 205 are as follows: A vertical
synchronization signal (hereinafter, referred to as
"Vsync"), a horizontal synchronization signal

20   (hereinafter, referred to as "Hsync"), a data-enable
signal (hereinafter, referred to as "DE"), and a dot
clock signal (hereinafter, referred to as "CLK").
Reference numerals 206 to 208 denote the above-
described signals' waveforms (incidentally, here, no

25   waveform is illustrated for the signal waveform of CLK).
Vsync 206 is a vertical synchronization signal for
indicating one frame time-period (i.e., time-period for
displaying one picture), and its frequency is set to be

60 Hz in the present embodiment. Hsync 207 is a horizontal synchronization signal for indicating one scanning time-period. DE 208 is a data-enable signal, and the display data becomes effective when this data-

5 enable signal is "HIGH". Here, this DE signal 208 becomes "LOW" for the time-period of several lines one time during the one frame time-period. This several-line time-period is referred to as "vertical blanking time-period". Meanwhile, concerning the display data

10 209, display data for the sub.screen which is in the non-displayed state is transferred during the above-described vertical blanking time-periods, and display data for the main screen is transferred during time-periods other than the vertical blanking time-periods.

15 Here, the display data for the main screen includes color information of, e.g., 16 bits (red: 5 bits, green: 6 bits, blue: 5 bits) per pixel. As the display data for the non-displayed sub screen, fixed data is selected which permits the power consumption of the sub

20 screen to become its minimum. In the present embodiment, black data (i.e., the display data for red, the one for green, and the one for blue are 0 all) is selected and transferred as the fixed data.

Next, the explanation will be given below

25 concerning driving timings of the respective screens. Numerals 210, 211, and 212 denote a scanning pulse for driving a first line of the main screen 203, a scanning pulse for driving a second line thereof, and a scanning

pulse for driving a third line thereof, respectively. Since the main screen 203 is in the displayed state, the scanning pulses are applied thereto sequentially on one scanning time-period basis in this way. On the

5 other hand, since the sub screen 204 is in the non-displayed state, there exists no necessity for applying scanning pulses thereto sequentially on one scanning time-period basis. In the case of using the liquid-crystal display apparatus or the like, however,

10 continuing to apply the direct-current components thereto degrades the liquid crystal because of the characteristics of the liquid crystal. This condition requires that the scanning pulses be applied thereto even in the non-displayed state so as to perform the

15 alternating-current driving. Consequently, it is advisable that, as illustrated in FIG. 2B, the scanning pulses be generated during the vertical blanking time-periods of the main screen 203, and that lines of the non-displayed sub screen 204 be driven sequentially on

20 each vertical blanking time-period basis of the main screen. Here, numerals 213 and 214 denote the scanning pulse for driving the first line of the sub screen 204 and the scanning pulse for driving the second line thereof, respectively. Both of the scanning pulses are

25 generated during the vertical blanking time-periods of the main screen 203.

From the above-described explanation, the operation frequency of the scanning pulses on the main

screen 203 becomes equal to the above-described frame
frequency = 60 Hz. On the other hand, on the sub
screen 204, each line of the sub screen is scanned
during the vertical blanking time-period of the main
5 screen 203. As a result, the operation frequency of
the scanning pulses becomes equal to 1/60 Hz. This
condition allows the non-displayed sub screen to be
driven with the low frequency, thereby making it
possible to implement the low power consumption.
10 Incidentally, during the vertical blanking time-periods
of the main screen, the main screen is also in the non-
displayed state.

Next, the description will be given below
regarding a detailed unit for performing the above-
15 described low power-consumption driving according to
the present invention.

FIG. 3 illustrates a configuration diagram in
the case where the display apparatus of the present
invention is applied to a mobile telephone. In FIG. 3,
20 numerals 301 and 302 denote a host station and the
mobile telephone, respectively. The basic
configuration blocks of the mobile telephone 302 are an
antenna 303, a transmission/reception unit 304, a CPU
305, a main memory 306, an input unit 307 and a display
25 unit 308. Also, the basic configuration blocks of the
display unit 308 are the data driver 201, the scan
driver 202, the main screen 203 and the sub screen 204.
Furthermore, the data driver 201 includes a system

interface 311, a volatile control register 312, a

timing adjusting unit 313, a memory control unit 314, a

memory 315, a tone-voltage generating unit 316, a tone-

voltage selector 317 and a scan driver interface 318.

5   Additionally, here, there may be provided three or more

screens.

At first, the CPU 305 inside the mobile

telephone 302 is an LSI for performing the respective

types of operation controls over the mobile telephone.

10 Regarding the screen control, the CPU 305 outputs the

display synchronization signals and display data 205 so

that received information from the host 301, or image

data stored in advance into the main memory 306 can be

displayed on the screens. Here, the display

15 synchronization signals and display data 205 are

prepared in the two types, i.e., the display

synchronization signals and display data 205 for the

main screen 203 and the one 205 for the sub screen 204.

For example, the one 205 for the main screen 203 is

20 outputted in the state where the mobile telephone is

opened, and the one 205 for the sub screen 204 is

outputted in the state where the mobile telephone is

folded. This operation can be implemented as follows,

for example: There is provided a switch which is

25 turned ON in the state of being folded. Then, the CPU

305 judges the state of this signal, and, depending on

this judgment result, selects the output. Also, in

addition to the above-described display synchronization

signals and display data 205, the CPU 305 outputs a display-operation control signal 310 for controlling the inner operation of the data driver 201 and that of the scan driver 202. The details of signal timings or

5   the like in the system interface will be omitted, since the description thereabout has been given in the above-described publications. Additionally, the outline of the operation lies in the following point: Instructions (i.e., data in the display-operation

10 control signal 310) are issued from the CPU, and this data is stored into the control register 312 inside the driver, thereby determining the operation inside the driver.

        Here, in order to implement the two-screen

15 driving method, i.e., the characteristic of the present invention, in addition to the instructions described in the above-described publications, the following four types of instructions are further added thereto in the present embodiment: The line number of the main screen

20 203 (hereinafter, referred to as "ML"), the line number of the sub screen 204 (hereinafter, referred to as "SL"), the line number of the vertical blanking time-period (hereinafter, referred to as "BL"), and information as to which of the screens is to be set

25 into the displayed state (hereinafter, referred to as "DS"). FIG. 4 illustrates an example of indicating into which address of the control register 312 the above-described instructions are to be stored.

Incidentally, in FIG. 4, the indication has been given
such that ML = 176 [decimal number], SL = 96 [decimal
number], BL = 4 [decimal number], and DS = 0 [binary
number]. This is an example for making the later-

5 described explanation easy to understand. Next, as
illustrated in FIG. 5, the sequence of issuing the
above-described instructions to the control register
312 is as follows: At first, at the time of an initial
setting before performing the display, the issuing of

10 all the four types of instructions is carried out.
After that, with respect to the information as to which
of the screens is to be set into the displayed state,
and the display synchronization signals and display
data 205 which are made compliance with this

15 information, their contents to be transferred are
modified whenever the need arises. This modification,
as described earlier, can be implemented as follows,
for example: There is provided the switch which is
turned ON in the state of being folded. Then, the CPU

20 305 judges the state of this signal, and performs the
control. The initial setting is performed for each
power-on into the data driver 201.

Next, the explanation will be given below
concerning the operation of the data driver 201 and the

25 scan driver 202 after the above-described instructions
have been stored into the control register 312.

At first, consider the case where the set
value indicated in FIG. 4 has been stored into the

control register. Since the DS signal is "0", the
above-described operation is set into the main-screen
display operation (i.e., sub-screen non-display
operation) mode. In this case, the display
5 synchronization signals 205 for the main screen 203 are
inputted into the memory control unit 314, and the
display data is written at a predetermined address in
the memory 315. Here, the addressing method is as
follows: In order to cause the address to coincide
10 with a displayed position on the main screen, based on
Vsync, the address is reset to the head address. Then,
the data is sequentially written in the transverse
direction in synchronization with the dot clocks in the
time-periods during which the DE signal is "HIGH", and,
15 based on Hsync, the line is returned to the new line.
This operation is repeated. Moreover, the "black data"
for the non-displayed sub screen, which is transferred
in the time-periods during which the DE signal is "LOW",
is written into the next line or thereafter to the
20 final line into which the display data for the main-
screen displaying operation is written.

        Next, the timing adjusting unit 313 receives
the display synchronization signals 205, then
generating read control signals for the memory 315 and
25 operation timing signals 320 for the scan driver 202.
FIG. 6 illustrates timing charts of these signals. In
FIG. 6, notations RST and CL1 denote a reset signal for
resetting the address to the head address and a read

synchronization signal, respectively. Based on these clocks, read data RDATA are sequentially outputted in unison on one-line amount basis from the memory 315. Next, the detailed items of the operation timing

5 signals 320 are FLM for indicating the head line, and CL3 for indicating output timings of scanning pulses. Incidentally, the above-described signal group can easily be generated from the inputted display synchronization signals 205 by a logic circuit, and

10 accordingly the detailed circuit configuration will be omitted.

The tone-voltage generating circuit 316 is a block for generating tone voltages in a level number corresponding to the display data. For example, the

15 level number in the present embodiment becomes equal to 64 levels, since, as described earlier, there exists the 6-bit green data.

The tone-voltage selector 317, in accordance with RDATA read from the memory 315, selects one level

20 from among the respective tone-voltage levels generated by the tone-voltage generating circuit 316, then outputting the selected one level as the tone voltage.

The operation described so far allows the tone voltages to be outputted in unison and in

25 synchronization with CL1. Moreover, after the output of all the tone voltages for the displayed unit has been terminated, a tone voltage corresponding to the black data is outputted. Furthermore, getting back to

the head line gain, this operation is repeated.

The transfer interface 318 is a block for transferring, to the scan driver 202, a part of the data stored in the control register 312. The

5   configuration and operation of the interface 318 are assumed to be in conformity with, e.g., "Common Driver Interface" described in the previously-mentioned Provisional Specification Rev 0.6 "256-color-display-capable RAM-built-in 384-channel segment driver

10   HD66763". The details of signal timings or the like in the common driver interface will be omitted, since the description thereabout has been given in the above-described publication.

Next, referring to FIG. 7, the explanation

15   will be given below regarding the configuration and operation of the scan driver 202. The scan driver 202 includes a control interface 701, a control register 702, a scanning-pulse generating circuit 703 and a level shifter 704.

20   The control interface 701 performs an operation of receiving instruction data transferred from the transfer interface 318, and of storing the instruction data into the control register 702. Here, the instruction data includes the above-described four

25   types of instructions ML, SL, BL and DS, i.e., the characteristic of the present invention,

The scanning-pulse generating circuit 703 is a block for determining to which output terminal and

with which timing a scanning pulse is to be outputted.
Here, this determination is performed based on the four
types of instruction data stored into the control
register 702, and the operation timing signals 320

5 transferred from the timing adjusting unit 313. For
example, as described earlier, in the case where ML =
176 [decimal number], SL = 96 [decimal number], BL = 4
[decimal number] and DS = 0 [binary number], as
illustrated in FIG. 8, signals D1 to D176 become the

10 ones for the main screen, and pulses occur sequentially
on one scanning time-period basis. Moreover, signals
D177 to D272 (= 176 + 96) become the ones for the sub
screen, and pulses occur sequentially on each vertical
blanking time-period basis. Generally speaking, in the

15 case where ML = m and SL = s, signals D1 to Dm become
the ones for the main screen, and signals Dm + 1 to Dm
+ s become the ones for the sub screen. Furthermore,
if DS = 0, the pulses for the main screen 203 occur
sequentially on one scanning time-period basis, and the

20 pulses for the sub screen 204 occur sequentially on
each vertical blanking time-period basis. If DS = 1,
on the contrary, the pulses for the main screen 203
occur sequentially on each vertical blanking time-
period basis, and the pulses for the sub screen 204

25 occur sequentially on one scanning time-period basis.

The level shifter 704 level-shifts the D
signal group outputted by the scanning-pulse generating
circuit 703, then outputting the level-shifted D signal

group to the scanning lines of each screen. The
criterions of the level-shift are a voltage level at
which the TFT is switched ON when a D signal is "HIGH",
and a voltage level at which the TFT is switched OFF
5   when the D signal is "LOW".

As having been described so far, in the data
driver 201, the tone voltages corresponding to the
display data are applied to the main screen 203 which
is in the displayed state, and the tone voltages
10   corresponding to the black data are applied to the sub
screen 204 which is in the non-displayed state.
Meanwhile, in the scan driver 202, the scanning pulses
are generated which can drive the main screen 203 on
one scanning time-period basis, and the scanning pulses
15   are generated which can drive the sub screen 204 on
each vertical blanking time-period basis. Then these
scanning pulses are sequentially applied to the
respective screens. This allows the non-displayed sub
screen to be driven with the low frequency.

20   Consequently, in the present embodiment, it
becomes possible to implement the driving of the two
screens, i.e., the main and sub screens, with the low
power consumption and without increasing the number and
areas of the configuration blocks, the cost and the
25   like.

Incidentally, in the first embodiment of the
present invention, the TFT liquid crystal has been used
as the screens. The present invention, however, is not

limited thereto. Namely, the present invention is
applicable to the other types of screens, e.g., an
organic EL screen. Also, in the first embodiment of
the present invention, the non-displayed sub screen has
been driven with the low frequency on each line and
vertical blanking time-period basis. The present
invention, however, is not limited thereto. Namely, a
plurality of lines may be driven simultaneously.

Also, in the first embodiment of the present
invention, the black data has been selected for the
display of the non-displayed sub screen. The present
invention, however, is not limited thereto. For
example, if liquid crystal in the normally-white mode
is used, applying white data thereto generally results
in the lower power consumption.

Namely, not being limited to the black data
or the white data, whatever display data is allowable
as long as its luminance is relatively low of the
plurality of tone voltages. Such low-luminance display
data are generically referred to as "blanking data".

Also, the first embodiment of the present
invention is easily applicable to the so-called partial
display mode.

Also, the display synchronization signals and
display data 205 in the first embodiment of the present
invention are transferred continuously by the raster
scan scheme. Accordingly, the memory 315, which is the
configuration block of the data driver 201, does not

necessarily store the display synchronization signals and display data 205 by the amount of one picture. Namely, for example, even a buffer by the amount of one line can meet the requirements.

In addition, as illustrated in FIG. 9, the display synchronization signals and display data 205 in the first embodiment of the present invention may also be configured to be generated and transferred by a graphic controller 901. The other configuration blocks are the same as those illustrated in FIG. 3, and accordingly are denoted by the same reference numerals.

Next, referring to FIG. 10 to FIG. 12, the explanation will be given below concerning the display apparatus in a second embodiment of the present invention. In the previously-described first embodiment of the present invention, the driving frequency of the screen which, of the two screens, is in the non-displayed state has been extremely lowered, thereby allowing the implementation of the low power consumption. In the second embodiment of the present invention, in addition to this characteristic, the presentation will be made regarding a method for reducing the power to be consumed at the tone-voltage generating unit. Also, the consideration will be given not only to the case of displaying either of the two screens, but also to the case of displaying the two screens simultaneously.

Hereinafter, referring to a timing chart in

FIG. 10, the explanation will be given below concerning the characteristics of the second embodiment of the present invention. In FIG. 10, FLM is a signal for indicating the head line, and CL3 is a signal for

5 indicating output timings of scanning pulses. These signals are the same as those in the first embodiment of the present invention. Power-supply signals are signals for controlling a tone-voltage generating unit. The tone-voltage generating unit is brought into

10 operation when the power-supply signal is "HIGH", and is brought into non-operation when the power-supply signal is "LOW". Tone voltages, which are outputted by a data driver, are at voltage levels corresponding to display data. Notations M1, M2, and M3 denote a

15 scanning pulse for driving a first line of the main screen, a scanning pulse for driving a second line thereof, and a scanning pulse for driving a third line thereof, respectively. Meanwhile, S1 and S2 denote a scanning pulse for driving a first line of the sub

20 screen, and a scanning pulse for driving a second line thereof, respectively.

At first, in the case of the two-screen simultaneous display mode, the power-supply signal is always "HIGH", and the tone voltage for the sub screen

25 is outputted subsequently to the tone voltage for the main screen. Being interrelated therewith, the scanning pulses for the sub screen are also outputted subsequently to the scanning pulses for the main screen

sequentially on one scanning time-period basis. Namely, in the two-screen simultaneous display mode, the main screen and the sub screen are driven as if they were one continuous screen. Next, in the main-screen

5 display mode, basically, the power-supply signal becomes "LOW" during display time-periods for the sub screen. However, in the proportion of one time (e.g., the shadow portion in FIG. 10) during a plurality of frame time-periods, the power-supply signal becomes

10 "HIGH" during the display time-periods for the sub screen. At this time, the tone voltage is outputted which is at a voltage level corresponding to display data (e.g., black data) which permits the power consumption to become its minimum. Being interrelated

15 therewith, the scanning pulses for the main screen are outputted on each frame time-period basis. The scanning pulses for the sub screen, however, are outputted in the proportion of one time during the plurality of frame time-periods. Incidentally, in the

20 sub-screen display mode, the above-described relationship becomes opposite.

As explained so far, in the display apparatus in the present embodiment, it turns out that, basically, the tone-voltage generating unit consumes the power

25 only during the time-periods during which the displayed screen or screens is or are being driven. Consequently, it becomes possible to expect an effect of reducing the power consumption at the tone-voltage generating unit.

FIG. 11 illustrates a configuration diagram
in the case where the display apparatus in the second
embodiment of the present invention is applied to a
mobile telephone. In FIG. 11, the reference numerals
5 denote the following configuration blocks,
respectively: 1101 a data driver, 1102 a scan driver,
1110 a timing generating unit, 1111 a memory control
unit, 1112 a memory, 1113 a power-supply control unit,
1114 a data converting unit, 1115 the tone-voltage
10 generating unit, and 1120 a display-operation control
signal and display data. The other configuration
blocks are the same as those in the first embodiment of
the present invention, and accordingly are denoted by
the same numerals.

15 At first, the main modified point in the data
driver 1101 is that, instead of being given the display
synchronization signals from the CPU, the data driver
1101 internally generates FLM and CL3 by itself. The
reason for this is as follows: If the display
20 synchronization signals are given from the outside,
there occur some limitations, e.g., the vertical
blanking time-periods become necessary by the amount of
several lines of the sub screen, thereby complicating
the control. Incidentally, using "the system
25 interface" described in the first embodiment of the
present invention, the display data is transferred from
the CPU, then being stored into the memory 1112. Also,
the memory 1112 is provided with a capacity capable of

storing both the main screen and the sub screen. This makes it possible to deal with both the two-screen simultaneous display and the one-screen displays even if no display data is transferred from the outside.

5   At first, the timing generating unit 1110 is a block for internally generating FLM and CL3 described above and RST and CL1, i.e., the memory read control signals. The contents of these signals are basically the same as those in the first embodiment of the

10   present invention. Also, when internally generating the signals, its easiest method is that an oscillator is built in the timing generating unit and its output is frequency-divided thereby to generate the signals.

         The memory control unit 1111 performs

15   operations of writing, at a predetermined address, the display data provided from the system interface 311. The details of these operations will be omitted, since the description thereabout has been given in the previously-mentioned Provisional Specification Rev 0. 6

20   "256-color-display-capable RAM-built-in 384-channel segment driver HD66763". Meanwhile, with respect to read operations, based on RST and CL1 generated at the timing generating unit 1110, the read data RDATA are outputted from the memory 1112 sequentially on one-line

25   amount basis in an order from the data for the main screen to the data for the sub screen. Moreover, when power-supply signals generated at the power-supply control unit 1113 described later are "LOW", the read

data are converted into "black data" at the data
converting unit 1114, then being transferred to the
tone-voltage selector.

In the respective types of display modes of
5   the main screen and the sub screen, the power-supply
control unit 1113 generates and outputs the power-
supply signals with the timings indicated in FIG. 10.
This operation can be implemented as follows: First,
the following information are given to the control
10 register 312 as instructions from the CPU: Information
about the line number of the main screen and that of
the sub screen, information about the display/non-
display operations, information indicating during how
many frame time-periods the non-displayed unit is to be
15 driven in the proportion of one time. Next, a logic
circuit using these values and RST and CL1 allows the
implementation of this operation.

Similarly with the first embodiment of the
present invention, the tone-voltage generating unit
20 1115 is a block for generating tone voltages in a level
number corresponding to the display data. For example,
as illustrated in FIG. 12, the unit 1115 includes
string resistors, operational amplifiers, and switches.
As its operation, at first, when the power-supply
25 signals are "HIGH", the switches are turned ON to
supply the power to each operational amplifier, thereby
generating the plurality of tone voltages. Moreover,
when the power-supply signals are "LOW", the switches

are turned OFF to stop the power supply to each
operational amplifier and direct currents flowing
through the string resistors. Consequently, the power
consumption at the tone-voltage generating unit 1115

5 becomes equal to 0. However, when the power-supply
signals are "HIGH", the following operation is also
allowable instead of supplying the power to all the
operational amplifiers: The power is supplied to only
an operational amplifier and a string resistor for

10 generating the tone voltage (i.e., lowest voltage)
corresponding to the black data, and the power supply
to operational amplifiers and string resistors for
generating the other tone voltages is stopped.

The configurations and operations of the

15 other blocks are the same as those in the first
embodiment of the present invention, and accordingly
the explanation thereof will be omitted.

The display apparatus in the second
embodiment of the present invention described so far

20 exhibits the effect of allowing the implementation of
the low power consumption by extremely lowering the
driving frequency of the screen which, of the two
screens, is in the non-displayed state. In addition
thereto, the display apparatus makes it possible to

25 reduce the power to be consumed at the tone-voltage
generating unit.

Incidentally, in the second embodiment of the
present invention, "black display" has been selected

for the display of the non-displayed screen. The

present invention, however, is not limited thereto.

For example, if liquid crystal in the normally-white

mode is used, applying white data thereto generally

5   results in the lower power consumption.

Also, the second embodiment of the present

invention is easily applicable to the so-called partial

display mode.

Incidentally, in the second embodiment of the

10   present invention, "black display" has been selected

for the display of the non-displayed screen. The

present invention, however, is not limited thereto, and

an arbitrary image may also be displayed. This display

can be easily implemented as follows: Desired image

15   data is stored in advance into a for-non-displayed-

screen area in the memory 1112. Then, RDATA to be read

therefrom is transferred to the tone-voltage selector

just as it is without being converted into "black data",

thereby implementing this display. At this time, as

20   the image data for the non-displayed screen, the RGB

eight-color display (with no immediate tones used) is

desirable where flicker is considered to be unlikely to

occur even in the low-frequency driving. Furthermore,

in order to implement the RGB eight-color display, it

25   is advisable to operate only operational amplifiers for

outputting V0 and V63 in FIG. 12. Accordingly, when

the power-supply signals are "LOW", there is provided a

unit for cutting operational amplifiers other than the

ones for outputting V0 and V63, and stationary currents flowing through the string resistors. This allows the acquisition of the power reduction effect close to the one by "black display".

5   Also, in the second embodiment of the present invention, the TFT liquid crystal has been used as the screens. The present invention, however, is not limited thereto. Namely, the present invention is applicable to the other types of screens, e.g., an

10 organic EL screen.

Also, in the second embodiment of the present invention, the display synchronization signals have been generated inside the apparatus. The present invention, however, is not limited thereto. Namely,

15 the present invention can also be implemented by generating basically the same signals outside the apparatus, and by transferring the signals thus generated.

Moreover, it is of course possible to

20 simultaneously implement both the functions in the first display apparatus of the present invention and the ones in the second display apparatus thereof.

According to the present invention, in the display apparatus where the separated two screens are

25 driven using the data lines common thereto, when setting either of the two screens into the displayed state, it is possible to extremely lower the scanning frequency of the other non-displayed screen. This

allows the implementation of the low power consumption. Also, the scanning pulses for the non-displayed screen driving are generated from the display signals for the displayed screen which are transferred from the outside

5 apparatus. This makes unnecessary a special control to be performed over the outside apparatus, thereby resulting in an excellent ease-to-use characteristic.

Furthermore, according to the present invention, it is possible to set the driver into the

10 operation state only during the time during which the displayed screen is being driven. This allows the implementation of the low power consumption inside the driver as well.

According to the present invention, the tone

15 voltage corresponding to the black data or the white data is applied to the display panel set in the non-displayed state. This makes it possible to prevent deteriorations in the display elements.

It should be further understood by those

20 skilled in the art that although the foregoing description has been made on embodiments of the invention, the invention is not limited thereto and various changes and modifications may be made without departing from the spirit of the invention and the

25 scope of the appended claims.